EFFECT OF FOOD SUPPLY ON GROWTH OF TILAPIA (TILAPIA MOSSAMBICA PETERS)

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The ability of the tropical African fish tilapia (Tilapia mossambica Peters) /498
to utilize the green mass of certain plant species was investigated in 1963 (N.V. Mironova. See the present collection). The object of that investigation was to discover whether the tilapia can be included in closed ecological systems as transformers of parts of plants not usable by man into first-class food proteins. The experiments were carried out on fish aged 8-13 months, i.e., sexually mature. In addition, fish grown in another laboratory and on various foods, including animal food, were used. The results obtained thus gave an idea merely of the extent to which the suggested plants could be eaten by the Tilapia and of the amounts of them to be included in the diet of fish fed on plant food.

It was not ascertained whether the tilapia can feed on this range of plants at an early age, whether it can live and grow on a purely plant diet, the effect of feeding on a plant diet on the size of the young fish, and the nature of the plants /499
most readily eaten and producing best growth of the fish. Another interesting problem is that of the effect of addition of a small amount of animal food to the plant diet on growth of the fish.

To answer these questions an experiment was carried out in 1964 in which tilapias were grown on various purely plant diets and mixed diets from an early age.

One of the females spawned on April 6, 1964, and produced larvae on April 24. After three days the larvae were taken from the mother and transferred into another aquarium. From that day and until the age of 48 days the larvae received a small amount of vinegar eelworm. In addition, from the 14th day they began to receive midge larvae ground in a mortar, and from the 19th day of life, ground fresh sorrel. At the age of two months all the young fish were measured and weighed (weight varied from 0.80 to 2.40 g), subdivided into nine groups each containing 8 fish, and placed in identical aquaria made of organic glass and with a volume of 40 liters. Starting from this moment the fish received food strictly in accordance with the diet stipulated for each aquarium (Table 1). As plant food they received sorrel, beetroot, radish and cabbage, i.e., plants belonging to different families. The long vegetation period and the accessibility of these plants meant that the fish could be maintained on the chosen diet until the age of 7 months.

All the fish were fed until satiated completely. The diets differed therefore not only in quality but also in quantity. Had the fish been given identical weights of food, their rates of growth would have reflected only the comparative food value of a particular item. The purpose of the experiment was different: to establish the quantity of different foods which the fish could consume and the weight they could attain when fed on different foods until complete satiation.

TABLE 1. Relative Percentages of Animal and Vegetable Foods in Diet of Tilapias of Different Groups in 1964

Aquarium No.	Number of Fish	Age, months				Species of Plants
		0–7		2–7		
		Animal food	Vegetable food	Animal food	Vegetable food	
5th aquarium (1963)	60	100	0	100	0	
26	8	69,8	30,2	75	25	Sorrel, beetroot, radish, cabbage (green leaves)
17	8	27,0	73,0	25	75	Sorrel, beetroot, radish, cabbage
23	8	26,4	73,6	25	75	Beetroot
21	8	26,1	73,8	25	75	Sorrel
25	8	27,1	72,8	25	75	Radish and cabbage
19	8	4,7	95,3	0	100	Sorrel, beetroot, radish, cabbage
22	8	2,3	97,7	0	100	Beetroot
20	8	2,1	97,9	0	100	Sorrel
24	8	2,5	97,5	0	100	Radish and cabbage

Commas represent decimal points.

Mean monthly 24-hour indices for fishes from different aquaria from 2 to 7 months of age are given in Table 2. For comparison this table, like all the subsequent tables, also include data for young fish grown in 1963 on purely animal food. The table shows the relationship previously observed (N. V. Mironova, see present collection) of a decrease in the 24-hour index with age and a higher absolute value of this index in fish receiving plant food only.

Tilapias not receiving animals food grew more slowly and by the age of seven months their length and weight were much smaller (Tables 3 and 4).

Fish receiving in their diet no more than 25% of midge larvae weighed no less than fish receiving 75 and 100% midge larvae (and in some cases exceeded them slightly). This suggests that to obtain a gain in weight equal to that of Tilapias fed on purely animal food, the diet need contain only 25%, or perhaps less, of animal food. /501

In none of the cased listed above can the diet given to the fish be regarded as balanced. The diet was extremely monotonous and could not provide the fish with a complete range of essential food substances. Very probably the addition of small amounts of substances used for intensifying growth of livestock to the diet would probably have resulted in much higher indices of weight increase.

TABLE 2. Twenty-four Hour Index of Tilapias for each Month of Life (Mean Daily Amount of Food Consumed as Percent of Body Weight of Fish)

Food from age of 2 months, %			Aquarium No.	Age, months				
Animal	Vegetable			2—3	3—4	4—5	5—6	6—7
100	0		Young fish 1963	22	18	11	8	5
75	25	Sorrel, beetroot, radish, cabbage	26	32	24	11	9	5
25	75	Sorrel, beetroot, radish, cabbage	17	38	27	18	14	12
25	75	Beetroot	23	49	31	19	14	11
25	75	Sorrel	21	40	33	27	17	13
25	75	Radish and cabbage	25	35	24	20	15	13
0	100	Sorrel, beetroot, radish, cabbage	19	41	35	28	19	19
0	100	Beetroot	22	75	51	32	25	18
0	100	Sorrel	20	49	40	44	35	22
0	100	Radish and cabbage	24	42	34	32	26	22

TABLE 3. Mean Length of Tilapias for each Month of Life (in mm)

Food from age of 2 months, %			Aquarium No.	Age, months					
Animal	Vegetable			2	3	4	5	6	7
100	0		Young fish 1963	40	64	83	97	109	122
75	25	Sorrel, beetroot, radish, cabbage	26	47	67	84	103	119	128
25	75	Sorrel, beetroot, radish, cabbage	17	45	62	79	93	105	116
25	75	Beetroot	23	44	66	82	95	110	122
25	75	Sorrel	21	47	67	85	101	115	131
25	75	Radish and cabbage	25	45	63	77	88	102	112
0	100	Sorrel, beetroot, radish, cabbage	19	45	61	72	83	88	95
0	100	Beetroot	22	44	57	69	79	83	87
0	100	Sorrel	20	45	60	71	83	94	103
0	100	Radish and cabbage	24	46	61	72	84	92	101

TABLE 4. Mean Weight of Tilapias for each Month of Life (in g)

Food from age of 2 months, %			Aquarium No.	Age, months					
Animal	Vegetable			2	3	4	5	6	7
100	0		Young fish 1963	1,2	5,3	10,6	16,2	21,9	30,8
75	25	Sorrel, beetroot, radish, cabbage	26	1,7	4,9	10,5	17,5	28,4	35,7
25	75	Sorrel, beetroot, radish, cabbage	17	1,4	4,0	8,3	13,7	18,5	24,7
25	75	Beetroot	23	1,4	4,9	9,9	19,8	23,4	32,2
25	75	Sorrel	21	1,6	4,9	10,3	18,2	27,3	38,1
25	75	Radish and cabbage	25	1,4	3,9	7,5	12,0	17,8	22,5
0	100	Sorrel, beetroot, radish, cabbage	19	1,4	3,7	6,1	12,6	11,2	13,4
0	100	Beetroot	22	1,4	3,0	5,8	12,3	10,5	12,3
0	100	Sorrel	20	1,4	3,3	5,4	9,1	13,6	17,3
0	100	Radish and cabbage	24	1,5	3,6	6,1	9,5	13,2	16,4

Commas represent decimal points.

TABLE 5. Food Index of Tilapias for each Month of Life (Ratio Between Raw Weight of Food Eaten Per Month and Increase in Weight of Fish during this Period)

Food from age of 2 months, %			Aquarium No.	Age, months				
Animal	Vegetable			2–3	3–4	4–5	5–6	6–8
100	0		Young fish 1963	5,8	7,9	8,7	8,9	6,4
75	25	Sorrel, beetroot, radish, cabbage	26	9,9	9,9	6,9	5,7	7,1
25	75	Sorrel, beetroot, radish, cabbage	17	11,5	12,2	13,6	14,7	13,8
25	75	Beetroot	23	12,8	14,2	9,0	25,0	10,9
25	75	Sorrel	21	11,7	14,6	15,3	13,1	11,4
25	75	Radish and cabbage	25	11,6	12,6	13,7	11,7	11,9
0	100	Sorrel, beetroot, radish, cabbage	19	14,4	22,1	12,7		31,8
0	100	Beetroot	22	31,0	24,5	14,1		34,8
0	100	Sorrel	20	18,1	27,0	26,8	26,7	24,4
0	100	Radish and cabbage	24	15,1	22,1	23,0	23,8	21,9

Commas represent decimal points.

The food indices (Table 5) of the foodstuffs tested correspond to the results obtained for the increase in weight. When animal or mixed diets were given, a more rapid rate of growth and lower values of food indices were obtained. Conversely, fish fed on vegetable food grew more slowly and the values of their food indices were higher.

Table 6 summarizes the data for four groups of fish over a period of 7 months. The greatest mean weight was attained by tilapias receiving 75% midge larvae and 25% plant food. Second place was occupied by fish receiving animal food. They differed only very slightly from fish receiving no more than 25% of midge larvae, the rest of the diet consisting of green mass of various vegetables.

Tilapias receiving no animal food whatsoever were only half the weight of those receiving 25% midge larvae.

TABLE 6. Mean and Total Weight of Tilapia Fry at the age of Seven Months, Total Amount of Food Consumed During this Period and Food Index in Relation to Diet

Food, %		Number of aquaria	Number of fish	Mean weight of fish, g	Σ weight of fish, g	Quantity of food consumed, g			FI
Animal	Vegetable					Animal	Vegetable	Total	
100	0	5	60	30.8	1848	13 178	—	13 178	7.1
69,8	30.2	1	8	35.7	286	1 560	675	2 235	7,8
26,6	73.4	4	32	29.4	941	3 166	8 731	11 897	12.6
2,7	97.2	4	32	14.8	475	316	11 056	11 372	23,9

Clearly the age at which the tilapias are transferred to a purely vegetable diet is very important. /504

The actual amount of the different foods given to the fish in order to reach a certain mean weight is shown in Table 7. These amounts are interesting as starting data for such investigations.

From these figures showing the gain in weight of the tilapias, their gain in weight per unit time per gram body weight can be calculated. Since the material at our disposal is still small, this calculation is approximate and provisional. The fish were weighed once a month. Information for the mean weight and gain in weight of the fish is therefore given relative to an interval of one month.

The results of this calculation are shown in Fig. 1. This was plotted from material for the growth of fish weighing from 1 to 58 g in nine experimental aquaria in 1968, and from summarized data for growth of tilapias in five aquaria in 1963 (Table 1).

TABLE 7. Total Quantity of Food Required for Growth of Tilapias of Different Ages and Weights

Aquarium No.	Proportion of food, %			Age, months											
				2		3		4		5		6		7	
	Animal	Vegetable		Mean Weight	Food eaten	Mean Weight	Food eaten	Mean Weight	Food eaten	Mean Weight	Food eaten	Mean Weight	Food eaten	Mean Weight	Food eaten
$1L_5$	100	0		1,36	4,5	4,59	26,4	10,2	69,0	15,4	115,2	21,1	179,2	30.0	233.2
$2L_5$	100	0		1,4	4,5	5,15	33,1	9,6	70,9	12,8	105,4	16,6	145,9	26.6	191.5
L_{10}	100	0		1,32	5.96	5,57	17,86	10,7	64,8	17,8	118,2	23,4	188,7	38.2	254.2
L_{5a}	100	0		1,05	4,3	5,34	29,3	12,6	87,9	18,7	141,5	24,6	179,8	31,1	223.1
L_{10a}	100	0		1,1	4,26	5,4	29,06	10,3	69,5	16,2	113,8	22,6	151,8	28,0	196.4
Mean				1,24	4,7	5,21	27,15	10,7	72,2	18,2	118,8	21,6	169,0	30,8	219.7
26	75	25	Sorrel, beetroot, radish, cabbage	1,7	10,9	4,9	43,1	10,5	98,6	17,5	147,7	28,4	210,7	35.7	268.8
17	25	75	Sorrel, beetroot, radish, cabbage	1,4	10,9	4,0	41,3	8,3	94,8	13,7	167,2	18,5	238,5	24,7	319.7
23	25	75	Beetroot	1,4	10,9	4,9	56,4	9,9	127,4	19,3	216,9	23,4	306,9	32,2	404.4
21	25	75	Sorrel	1,6	10,9	4,9	49,4	10,3	127,9	18,2	249,4	27,3	368,4	38,1	492.4
25	25	75	Radish and cabbage	1,4	10,9	3,9	39,9	7,5	84,9	12,0	147,4	17,8	216,4	22,5	271.4
Mean				1,4	10,9	4,4	46,7	9,0	108,7	15,8	195,2	21,7	282.5	29.4	371.9
19	0	100	Sorrel, beetroot, radish, cabbage	1,4	10,9	3,7	42,8	6,1	97,3	12,6	179,8	11,2	247.8	13.4	318.3
22	0	100	Beetroot	1,4	10,9	3,0	61,4	5,8	131,9	12,3	222,9	10,5	307,9	12.3	371.4
20	0	100	Sorrel	1,4	10,9	3,3	45,4	5,4	100,9	9,1	200,4	13,6	319,9	17,3	424.3
24	0	100	Radish and cabbage	1,5	10,9	3,6	43,4	6,1	97,9	9,5	175,4	13,2	265,4	16.4	333.9
Mean				1,4	10,9	3,4	48,2	5,8	107,0	10,9	194,6	12,1	285.2	14.8	361.9

Commas represent decimal points.

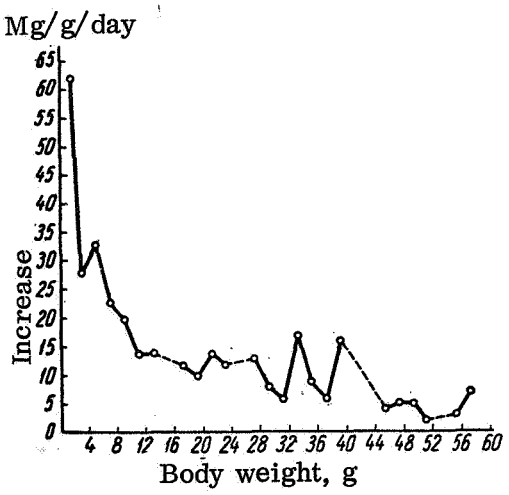

Figure 1. Increase in Weight of Tilapias.

For a body weight of up to 2 g the daily increase in wight is 62 mg/g body weight. For a body weight over 50 g the daily increase falls to 2-7 mg.

The results of this investigation show that tilapias can utilize the green mass of higher plants not merely in the adult, sexually mature state, but also from the age of two (or even one) months, when their body weight is about 1 g. Thereafter they can live and grow for long periods (5 months) when fed purely on vegetable food, even if this consists only of plants of one species. A small addition by weight of animal food has a considerable influence under these circumstances on the rate of growth, doubling it compared with the growth of fish receiving vegetable food only. /505

The results described above demonstrate the considerable plasticity of growth of the tilapia and the possibility of its intensification by the addition of small amounts of first-class food (for example, waste products from the fish themselves resulting from cooking, Chlorella, and perhaps vitamins).

Further investigations will be carried out to study methods of increasing growth of the tilapia.